**Revision:**

* Last time we started talking about requirements of dental cements
* Also we talked about mixing powder and liquid; in which we don’t usually end up in total involvement of them together; instead, we would have a core of unreacted powder that is surrounded by matrix (reacted powder and liquid).
* What specializes luting cement from other basic cements is that it has a small film thickness (25 **µm**).
* What are the functions of dental cement? 1) Liner 2) Fillling (only glass ionomer is used as a filler) 3)Bases

4)Endodontic treatment 5) Luting the crown.

* What are the benefits of using dental cements? 1) Palliative (sedative effect) 2) Protective 3) Curing effect.

**we are going to talk about calcium hydroxide:**

* Calcium hydroxide is either:

🡪 Chemically cured

🡪Or light cured meaning that it must be exposed to light to be cured,

 The light cured calcium hydroxide advantage is that the dentist gets to control the time of setting of material; after he/she places the Ca(OH)2 in the cavity & shapes it as he/she wants, he/she would then apply the light causing the material to harden. However, chemical cured calcium hydroxide has a specific limited time to set in which after that, the material will harden and can't undergo further manipulation. However, light cure is not widely used because it's expensive and the advantage it offers is not of a weight because chemical cure is working well and the time it provides is enough.

* Calcium Hydroxide Cement composition:

**Base:**

1-calcium hydroxide (50%)

2-Zinc Oxide (10%)

3-Sulfanomide (39.5%) (Carrier)

4- Zinc stearate(0.5%)(accelerator)

Calcium hydroxide and zinc oxide are the main primary reactive components.

**Catalyst:** 40% glyconyl salicylate with varying amounts of pigments to give radiopacity and colour, such as titanium dioxide and calcium tungstate or barium sulphatethese and even after the addition of these pigmentations we usually don't see the calcium hydroxide cement ...the dentine, enamel, and amalgam are all more radio opaque.

* **Properties:**
1. Calcium hydroxide has a low compressive strength & it barely withstands the condensation of amalgam, thus it is only applied to the floor unlike the varnish that is applied to both walls and floor of cavity.

2- Calcium hydroxide has an alkaline pH (11-12). We benefit from this property in two ways:

a) When applied to the dentine, the alkaline medium will attack the acidic medium of bacteria thus it acts as an **antibacterial** substance.

b) Secondly, if we encountered an exposed pulp we apply calcium hydroxide cement (direct pulp capping), and because of its high pH it will cause irritation and inflammation of pulp thus causing the formation of 2ndry dentine which forms a bridge of dentin-like material that isolates the pulp preventing us from using root canal treatment.

3-Does not provide any significant thermal insulation or electrical insulator!

4- Radiolucent.

5- Compatible with all fillings, e.g.: Zinc oxide eugenol is not compatible with composites, unlike calcium hydroxide which can be applied with any filling.

6- High solubility: That’s why it should only be applied to the floor, NOT to the walls, because if applied to the walls it's going to dissolve with time forming a space for the leakage of saliva and secondary caries.

* Other important usage for calcium hydroxide:

We all know that when a tooth is erupted its root still needs 3 years to be fully formed. What if at this time the tooth became damaged and needed a root canal?!

What we do is we apply calcium hydroxide at the end of the opening. As we said calcium hydroxide will stimulate formation of 2ndry dentine thus we're completing the rest of the root. After that we can start root canal treatment. This process is called **apexification**.

**Now we are going to talk about Zinc Oxide Based-Cements**:

* These Zinc Oxide based-cements contain zinc oxide such as zinc oxide eugenol, zinc oxide phosphate, and zinc oxide polycarboxylate.
* One component is powder and the other is liquid:

1) Zinc oxide eugenol🡪Powder: Zinc Oxide.

 Liquid: Eugenol.

2) Zinc oxide phosphate🡪Powder: Zinc oxide.

 Liquid: Phosphoric acid.

3) Zinc oxide polycarboxylate🡪Powder: Zinc oxide.

 Liquid: polyacrylic acid.

**Zinc Oxide Eugenol**

* Zinc oxide eugenol is either modified or unmodified. The unmodified form is the old original one. They can then modify it by adding ethoxybenzoylacid so that it becomes ethoxybenzoylacid modified zinc oxide eugenol abbreviated as EBA-modified zinc oxide eugenol. The modified form is of much more strength & less solubility (more resistant to water). The original problem of solubility is from eugenol; it's easily leachable, so in the modified form, the percentage of eugenol is less & ethoxybenzoylacid is more making it less soluble.
* Components of zinc oxide eugenol:

In the powder part 🡪we have zinc oxide, Zinc stearate (accelerator), Zinc acetate (improves strength) & other substances.

In the liquid part🡪 we have eugonel -that’s going to react with zinc oxide-, & olive oil (modifies the viscosity & plasticizer).

* A special feature of zinc oxide eugenol is that it’s the least irritable & the most sedative- meaning, when applied to the patient the pain is revealed-. Researchers say that it's sedative not because it’s a painkiller but because it closes dentinal tubules completely so no dentinal fluid motion happens, & thus no toxins or bacteria enter. That’s why it's good for deep dentine. This is unlike zinc oxide phosphate which is very irritable, & thus is not applied to deep cavities (deep dentine) in the first 24-48 hours, but applied after several days instead.
* Zinc oxide phosphate contains phosphoric acid, thus its pH is 2 and it will irritate the pulp if we apply it directly. However this is not the case with zinc oxide carboxylate eventhough zinc oxide carboxylate also contains acid polyacrylic acid with pH=2… This is because the polyarcylic acid molecules are large and lack mobility so they can't enter dentinal tubules.
* All Zinc Oxide-Based Cements are good thermal insulators; when applied under amalgam would not cause shock after drinking/eating hot & cold drinks/food.
* Cements are either in tooth paste form or powder/ liquid form. The powder/liquid ratio is very important. Usually, the powder is more than liquid to ensure consistency & to decrease solubility. If I increased the liquid in order to make it easier to deal with material & to finish working on the patient as fast as possible, then I would be increasing the solubility & decreasing strength & that, of course, is not desirable.
* In zinc oxide eugenol the ratio of powder to liquid equals 4 spoons of powder to each drop of liquid. How do we mix them? By adding powder in small increments to the liquid & mixing them in COLD glass slab (as temp. decreases🡪 working time increases), & by working on a LARGE area (as we increase the area we increase working time & reduce the setting time) & by mixing slowly to increase the working time.

🡪Working time: the time from mixing the material till I finish working.

🡪Setting time: the material doesn’t undergo further manipulation after this.

\*ideally working time should be more & setting time is preferably less.\*

* Usually the reaction between molecules occurs in several steps & the final mixture consists of particles of Zinc-oxide embedded in a matrix of Zinc eugenolate. Particles of Zinc-oxide are not present for the naked eye; they are like crystals which we only see on microstructure basis.
* ZOE material set faster in the mouth than out of the mouth, why is that? Because the body temp. is higher making setting time less.
* Water enhances setting time of ZOE so we can place cotton soaked with water on it to enhance setting time. Why don’t we depend on saliva even though it contains water? That’s because saliva would leach/dissolve it.
* The complete setting time takes up to 24 hours.
* In conclusion, setting time is affected by a number of factors:

**Particle size**: Smaller zinc oxide particle sets faster.

**Accelerators**: Alcohol and water will accelerate the setting reaction.

**Heat**: Cooling the glass slab slows the reaction.

**Powder to liquid ratio**: the higher the **ratio**, faster the set.

* Zinc oxide eugenol can't be used under composite filling because it would break; that's why they manufactured zinc oxide free-eugenol.

**Zinc OxidePhosphate**

* Eventhough it does irritation to the pulp because of its high acidity, it is still widely used because it has a very good sealing characteristic & high strength & is less soluble than zinc oxide eugenol. We usually use it under amalgam because it's a good thermal insulator.

🡪Regarding deep cavities we line them with calcium hydroxide then we apply zinc oxide phosphate & finally we apply amalgam. However in intermediate cavities we apply the zinc oxide phosphate direct to the base & then amalgam.

* Why don't we apply calcium hydroxide to the intermediate cavity? Because amalgam needs bulk sections as in thin sections it breaks🡪In deep cavities we have space for calcium hydroxide to close the dentinal tubules & stimulate 2ndry dentine formation and then to apply zinc oxide phosphate for insulation and then amalgam but in intermediate cavities we need every millimetre cause the more the bulk the stronger the connection so we don’t apply calcium hydroxide for more space and also it's an intermediate cavity so no irritation.
* Composition:

Powder: Zinc Oxide, magnesium, silica and other oxides

Liquid: Phosphoric acid, water, aluminium, aluminium phosphate, zinc.

* Setting reaction:

First reaction: Zinc oxide + Liquid 🡆 Zn (H2PO4)2 + H2O

 ZnO + 2H3PO4 🡪 Acid zinc phosphate

Further reaction: ZnO + Zn(H2PO4)2 + 2H2O 🡆 Zn3(PO4)2(Hopeite) + 4H2O

🡪Hopeite has a crystalline structure that gives strength to the structure.

* Zinc oxide phosphate has a wide range of uses for example it's used in luting.
* In zinc oxide phosphate the ratio is 3 increments of powder to 1 drop of phosphoric acid we mix them in a circular motion on cold glass slab.
* Its working time is 6mins.
* Freshly mixed 🡆 pH 1.3-3.6 🡆 persisting up to 24h 🡆 then returns to near neutral pH.
* Just like the zinc oxide eugenol it needs 24h to completely set.
* Compressive strength is more than (modified and unmodified) Zinc eugenol.
* Good thermal insulator and has less solubility than varnish, calcium hydroxide and zinc eugenol.

**Zinc Oxide Polycarboxylate**

The first dental cement to chemically adhere with enamel and dentine, however the adherence is low. 